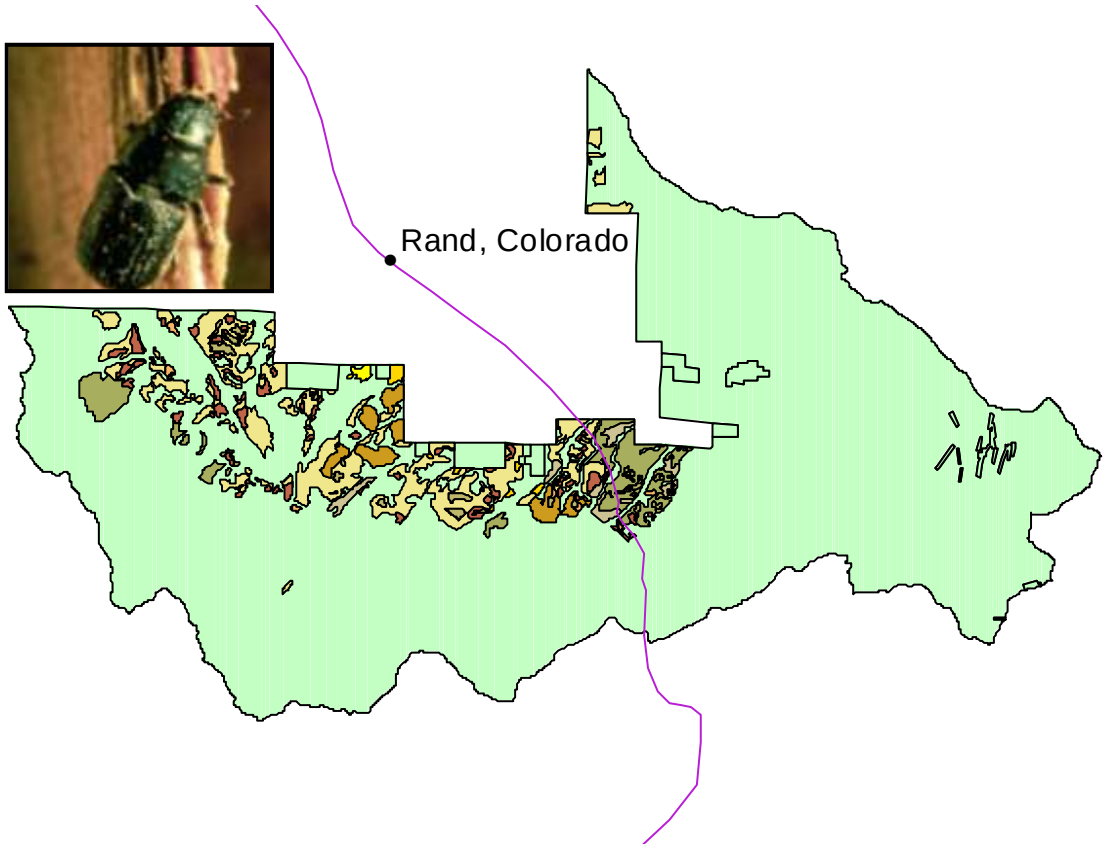
Biological Evaluation
R2-03-05

Biological Evaluation of Mountain Pine Beetle Activity on the Green Ridge Analysis Area of Parks Ranger District, Medicine Bow-Routt National Forest, 2003



Biological Evaluation
R2-03-05

Biological Evaluation of Mountain Pine Beetle Activity on the Green Ridge Area of Parks Ranger District, Medicine Bow-Routt National Forest, 2003

February 2003

Prepared by:

_____

Robert J. Cain
Entomologist, Lakewood Service Center (LSC), Forest Health Management

And

_____

Carl L. Jorgensen
Biological Technician, LSC, Forest Health Management

Approved by:

_____

Jeffrey J. Witcosky
Entomologist and Leader, LSC, Forest Health Management

And

_____

Frank J. Cross
Group Leader, Forest Health Management

USDA Forest Service
Rocky Mountain Region
Renewable Resources
PO Box 25127
Lakewood, CO 80225-0127

Abstract

A dramatic increase in mountain pine beetle (MPB) activity and lodgepole pine mortality was seen in recent years on the Parks Ranger District, Medicine Bow-Routt National Forests and adjacent lands near Rand, Colorado. A variety of silvicultural treatments on over 8,000 acres of National Forest Lands to reduce MPB infestations and tree mortality are proposed to be conducted within an area designated the Green Ridge Analysis Area. MPB conditions for the proposed treatment areas were estimated by strip samples, systematic 1/50th acre plot samples, and by aerial surveys. Ground surveys recorded the number of currently infested trees and the number of MPB-killed trees in 2001. Strip samples were conducted in the central and southeastern portion of the analysis area which is referred to in this evaluation as the Willow Creek Area. Systematic 1/50th acre plot samples were conducted on the western end of the analysis area which is referred to as the Green Ridge Area. No ground survey was conducted on the northeastern portion of the analysis area referred to as the Owl Mountain Area. Stand susceptibility was evaluated by summarizing Parks Ranger District stand exam data.

MPB survey data indicates a high level of beetle activity in the Green Ridge Analysis Area and a high risk of infestation to all susceptible stands in the proposed treatment areas covering over 8,000 acres. Average stand diameters, age, tree density and elevation indicate all stands in the proposed treatment areas are moderately to highly susceptible to MPB outbreaks. Management efforts in the proposed treatment areas can help reduce MPB impacts and reduce stand susceptibility to MPB attack.

Introduction

Mountain pine beetle (MPB) (*Dendroctonus ponderosae* Hopkins) is a native insect that plays a major ecological role in maturing lodgepole pine forests. MPB epidemics can cause dramatic tree mortality over extensive areas and the insect has been described as the most important biotic agent of change in western pine forests (Amman et al. 1989). MPB kills trees by feeding on the phloem tissue and by introducing a blue stain fungus, *Ceratocystis montia* (Rumb) Hunt, which blocks the water conducting xylem tissue. MPB outbreaks reduce average stand diameter and age, and influence such things as canopy closure, stand structure, species composition, forage production, wildlife habitat, fuel loading, water yield and aesthetics. Downfall and woody debris following infestations can also hamper access by livestock, big game and humans (McGregor and Cole 1985).

Amman et al. (1977) developed a risk rating system for classifying lodgepole stand susceptibility for MPB epidemics based on average diameter at breast height (dbh), average age, and stand elevation and latitude. Lodgepole pine stands that are highly susceptible to MPB typically have the following characteristics: average dbh > 8 inches; average age > 80 years; and a suitable climate for beetle development determined by elevation and latitude (Amman et. al. 1977). Suitable climate for beetle development based on the latitude for the Green Ridge Analysis Area is estimated to be between 8,800 and 9,800 feet for moderate risk and below 8,800 feet for high risk. Close proximity of MPB populations also increases the risk for tree mortality in susceptible stands (Shore and Safranyik 1992). Studies in ponderosa pine indicate that tree densities above 120 sq. feet of basal area per acre are also more favorable to MPB than are less dense stands (Schmid and Mata 1992). The 120 sq. ft. basal area threshold may also be pertinent in lodgepole pine stands. Studies in lodgepole pine found greater losses in stands thinned to 120 sq. ft. basal area and in unthinned control plots compared to stands thinned to 100 or less sq. ft. basal area per acre (McGregor et al. 1987).

Outbreaks of MPB tend to occur at intervals of fifteen to twenty years in older Rocky Mountain lodgepole pine forests and may last for six to ten years (Cole and Amman 1980). Between outbreaks, low level populations persist by selecting weakened or damaged trees, but no such selection is evident during high level populations (Furniss and Carolin 1977). Once an epidemic is underway, most large trees in the outbreak area may be attacked (Cole and Amman 1980). Smaller diameter and younger trees in and near outbreaks may be attacked and killed, but small trees alone are not capable of sustaining an outbreak (McGregor and Cole 1985). Stands having a large proportion of large diameter trees with thick phloem are most likely to be infested and will suffer proportionately greater losses (Amman et al. 1977). Stress factors, such as current drought conditions, may contribute to stand susceptibility, but the exact triggering mechanism of MPB outbreaks is not known. MPB epidemics do not

require a landscape disturbance, such as fire or windthrow to be initiated or to spread. When factors favorable to MPB population increases coincide with host susceptibility, beetle outbreaks can result.

Current Situation

The Green Ridge Analysis Area is located on the Parks Ranger District of the Medicine Bow-Routt National Forests in the Rabbit Ears Range west, south, and east of Rand, Colorado. Elevation ranges from 8,600 feet to over 12,000 feet. Lodgepole pine and scattered aspen dominate the forested areas in the lower elevation range and Englemann spruce and subalpine fir are found on the wetter, higher and steeper forest sites. Lodgepole pine stands are also found on adjacent BLM, state, and private lands.

Aerial survey detected tree mortality from MPB in the Green Ridge Area beginning in the late 1990's and a dramatic increase was seen in 2001. Much of the current beetle activity is occurring at lower elevation where many moderately and highly susceptible lodgepole pines stands dominate the landscape. There is potential for this MPB epidemic to affect contiguous lodgepole pine forests on National Forest, Bureau of Land Management, State and private lands.

The proposed action includes a mix of treatment activities designed to prevent and suppress the spread of MPB from currently infested lodgepole pines to uninfested lodgepole pines and to salvage dead and infested trees. Areas that are not currently infested but have a moderate to high risk for MPB infestation will be preventively thinned to reduce the susceptibility to beetles. Silvicultural treatments are proposed on 8,078 acres within the analysis area. Proposed treatments ranked by area include sanitation/salvage (53%), shelterwood prep (20%), clearcut (10%), past harvest salvage (9%), overstory removal seed cut (5%), conifer removal from aspen (1%) and overstory removal (1%) (Scoping Report for the Green Ridge MPB Analysis, July 2002).

Purpose

This evaluation documents the current status of MPB on the Green Ridge Analysis Area and evaluates the proposed treatments for suppressing MPB, preventing its spread to uninfested stands, and salvaging areas already impacted.

Methods

Current MPB conditions for the Green Ridge Analysis Area were estimated by aerial survey, strip samples and systematic1/50th acre plot samples. Stand susceptibility was evaluated by summarizing stand exam data.

Aerial Survey

Aerial surveys were conducted from a fixed wing single engine aircraft about 1,500 feet above the ground at approximately 100 miles per hour in August after infested trees began to fade. Erik Johnson (Aerial Survey Program Manager, FHM) performed the aerial surveys. Areas of lodgepole pine killed by mountain pine beetle were sketch mapped onto 1:100,000 scale USGS 30X60 minute topographic maps. Estimated tree mortality and acres affected by MPB across all land ownerships in the Rand area were summarized for six of the last seven years, excluding 1997 when the area was not flown.

Ground Survey

The Green Ridge Analysis Area was divided into three regions (Figure 1) based on the MPB sampling method used by the Parks Ranger District survey crew.

The Green Ridge area includes the proposed treatment areas on the western end of the Green Ridge Analysis Area. In this area, 1,354 1/50th acre plots were systematically taken across the proposed treatment areas by Parks Ranger District personnel (Figure 2). The number of currently infested trees and the number of trees killed in 2001 were recorded within each plot.

The Willow Creek area includes the proposed treatment units in the central and southeastern portion of the Green Ridge Analysis Area. The sampling method used by Parks Ranger District personnel in this area was strip samples approximately 33 feet wide and covering approximately 60 miles (Figure 2). 1/50th acre plots were taken where infested trees were encountered along the transect. Lakewood Service Center personnel sampled a 66 feet wide strip totaling 1.5 miles and covering about 12 acres in this area. Currently infested and one year old MPB-killed trees were recorded.

The third area identified was Owl Mountain located in the northeastern part of the Green Ridge Analysis Area. There are only four proposed treatment areas covering 199 acres in this area. No ground surveys were conducted and only stand basal area and aerial survey data were available.

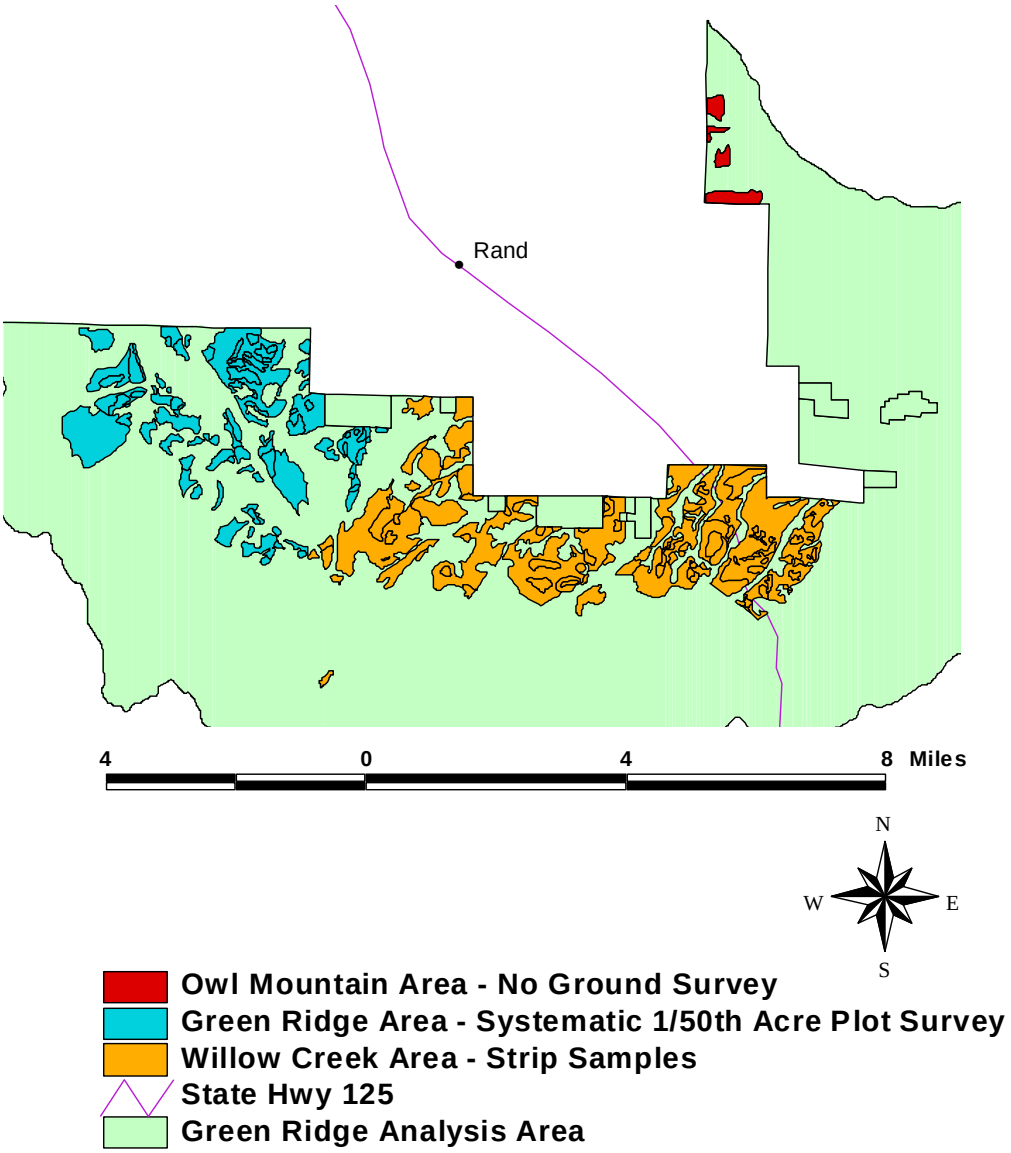


Figure 1. Proposed treatment areas separated by MPB survey method.

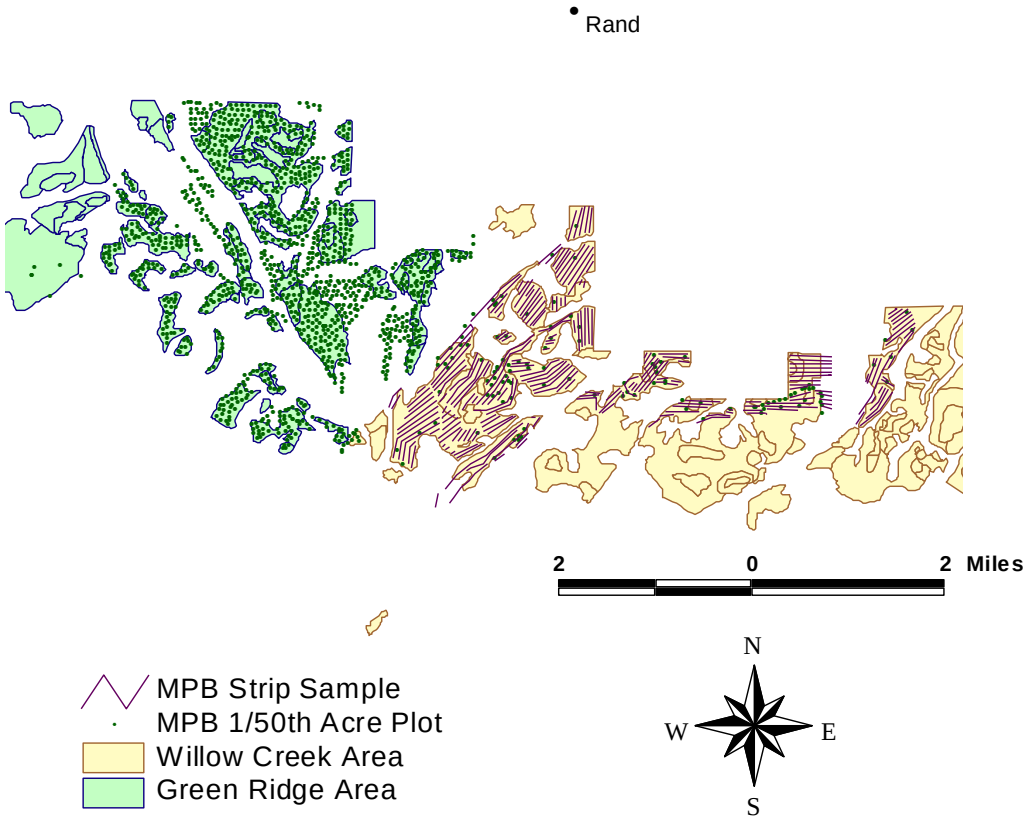


Figure 2. Areas ground surveyed for MPB activity by the Parks Ranger District.

Stand Data

Stand exam data was provided for all proposed treatment areas by the Parks District of the Medicine Bow-Routt National Forest. Data were separated into three groups based on the MPB survey method used (Figure 1) and then summarized for each of the proposed silvicultural treatments (Tables 3, 4, and 5). Averages were determined by weighting the mean for individual stand data based on the percent of acreage each stand occupied for the proposed treatment activity. The overall average weighted the averages based on the total acreage for each proposed treatment. Data for "no treatment" units were not included. Summarized data were used to evaluate the susceptibility of stands within each proposed type of silvicultural treatment. Stand exam information was unavailable for one thirteen acre proposed sanitation/salvage treatment area and was excluded from the summary.

Results and Discussion

Aerial Survey

Aerial survey data indicate an increasing trend for MPB in the Green Ridge Analysis Area. Aerial survey data provide only general trend information on pest activity because flying conditions and surveyors may vary from year to year. It appears that the intensity of the MPB outbreak was initially greater in the Green Ridge area on the western end of the analysis area. The intensity of dying trees has remained high in this area while increasing in the Willow Creek and Owl Mountain areas over the last two years. (Table 1 and Figure 3).

Table 1. Aerial Survey results for Green Ridge Analysis Area including adjacent private and federal lands.

Year	Area impacted by MPB* (acres)	Estimated number of trees killed by MPB*
2002	8,608	14,175
2001	9,596	31,740
2000	2,900	4,972
1999	2,273	4,000
1998	736	949
1997	No data	No data
1996	100	121

* Due to the nature of aerial survey these numbers are rough estimates and are presented only to show trends and not to be used in data analysis.

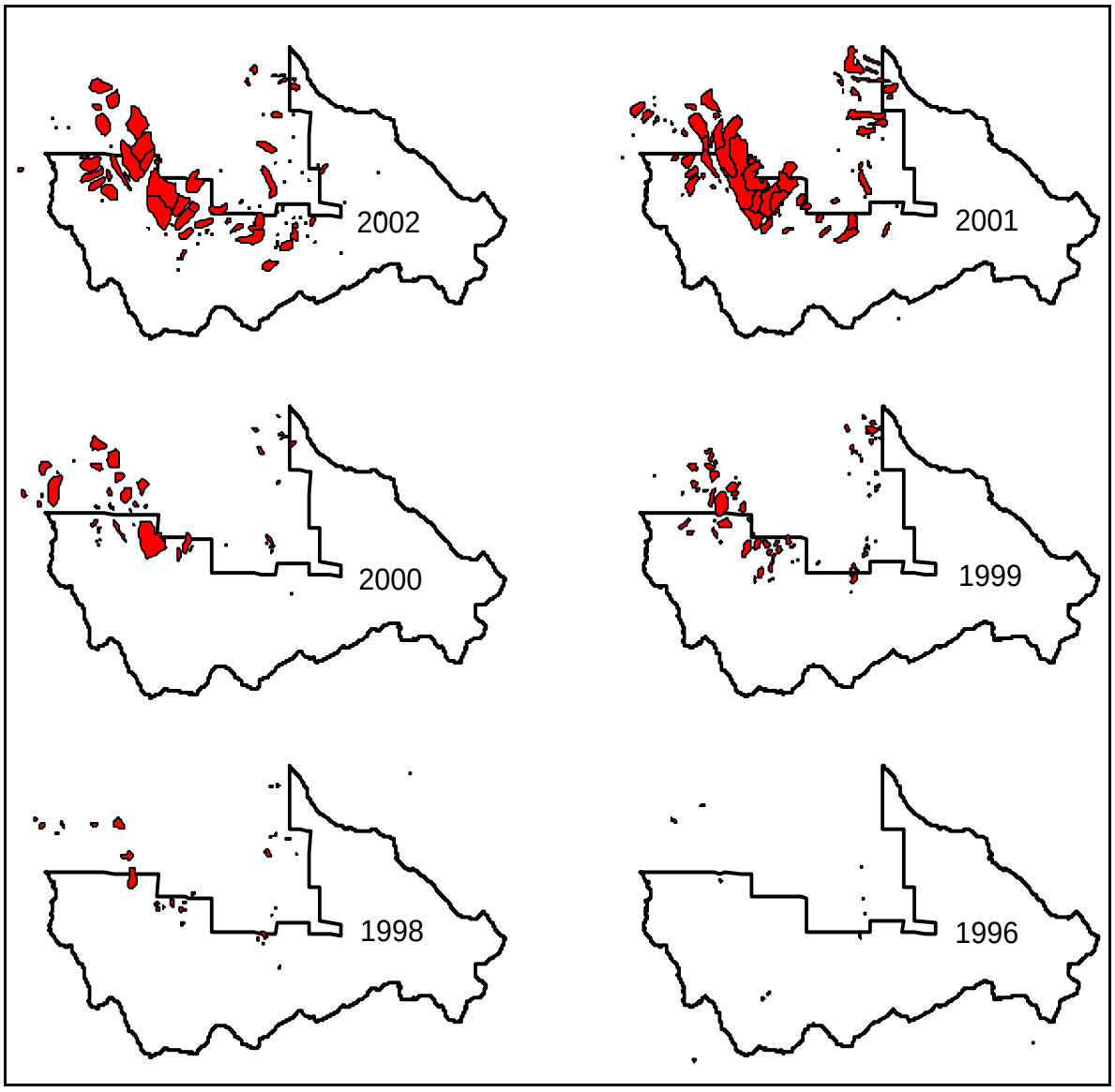


Figure 3. MPB activity detected by aerial surveys* conducted 1996-2002 over the Green Ridge Analysis Area and adjacent lands.

***Disclaimer**: Due to the nature of aerial surveys, the data on this map will only provide rough estimates of location, and the resulting trend information. These data should only be used as an indicator of insect and disease activity, and should be validated on the ground for actual location and casual agent. Shaded areas show locations where trees were killed. Intensity of damage is variable and not all trees in shaded areas are dead. The data represented on this map are available digitally from the USDA Forest Service, R2 FHM. The cooperators reserve the right to correct, update, modify or replace GIS products. Using this map for purposes other than those for which it was intended may yield inaccurate or misleading results.

Stand Conditions

Stand exam data for the proposed treatment areas indicate current stand conditions are favorable for continued losses MPB losses. Amman et al. (1977) developed a risk rating system for classifying stand susceptibility for MPB epidemics based on average DBH, average age, and stand elevation and latitude (Table 2). Risk factors (1-3) are multiplied to obtain a stand's susceptibility classification (1-9 = low risk, 12-18 = moderate risk, 27 = high risk).

Table 2. Factors for determining stand susceptibility to MPB.

Elev. at Lat. 40.4°		Average Age		Average DBH	
<8,800 feet	(3)	> 80	(3)	> 8 inches	(3)
8,800-9,800	(2)	60-80	(2)	7-8 inches	(2)
>9,800	(1)	< 60	(1)	< 7 inches	(1)

Stands in Green Ridge Analysis Area are all over 8 inches dbh and over 80 years old (Tables 3 and 4) and are moderately to highly susceptible to MPB outbreaks based on elevation. Most of the proposed treatment areas are in the higher risk, low elevation locations but significant tree mortality may still be seen in stands at moderate risk above 8,800 feet.

Stand basal areas can also be an indicator of susceptibility. Basal areas above 120 sq. ft. per acre have been shown to be more likely to be attacked by MPB in ponderosa pine stands (Shmid and Mata 1992) and there are studies that indicate the same may be true for lodgepole pine stands (McGregor et al. 1987). Basal area in the Green Ridge Area, the Willow Creek Area and the Owl Mountain Area all indicate potentially vulnerable stands to MPB.

Table 3. Stand data by proposed silvicultural treatments for the Willow Creek Area.

Proposed Treatment	Number of units proposed	Total acres in all units	% of Total Acres	Average* DBH (inches)	Average* Age (years)	Average* Basal Area(sq. ft./ac)	Average* Basal Area aft. Tmt.
Clearcut	29	338	7	8.5	117	151	2
Overstory Removal	5	47	1	8.3	96	121	50
Sanitation/ Salvage	15	2301	46	8.7	110	145	90
Past Harvest Salvage	6	727	15	8.5	103	132	109
Shelterwood	6	1056	21	8.5	109	171	100
Overstory Removal/Seed Tree	8	409	8	9.0	101	117	51
Conifer Removal from Aspen	7	114	2	8.2	98	127	63
Total/ Overall Average*	76	4992	100%	8.6	108	146	

*Averages were determined by weighting the mean for individual stand data based on the percent of acreage each stand occupied for the proposed treatment activity. The overall average weighted the averages based on the total acreage for each proposed treatment. Data for "no treatment" units was not included.

Table 4. Stand data by proposed silvicultural treatments for the Green Ridge Area.

Proposed Treatment	Number of Units Proposed	Total Acres in all units	% of Total Acres	Average* DBH (inches)	Average* Age (years)	Average* Basal Area (sq.ft./ac.)	Average* Basal Area aft. Tmt.
Clearcut	38	492	17	9.0	124	163	0
Overstory Removal	2	43	2	10.0	114	171	74
Sanitation/ Salvage	32	1782**	62	9.0	119	169	98
Shelterwood	7	556	19	8.3	146	212	127
Total/ Overall Average*	79	2873	100%	8.9	125	176	

*Averages were determined by weighting the mean for individual stand data based on the percent of acreage each stand occupied for the proposed treatment activity. The overall average weighted the averages based on the total acreage for each proposed treatment. Data for "no treatment" units was not included.

** Stand exam data was unavailable for a thirteen acre proposed sanitation/salvage treatment area and was not included in the summary.

Table 5. Available* stand data for the proposed silvicultural treatment in the Owl Mountain Area.

Proposed Treatment	Number of Units Proposed	Total Acres	Average** Basal Area (sq. ft/ac.)	Average** Basal Area after Tmt.
Sanitation/Salvage	4	199	187	113

* No stand age or diameter information was available for the stands in the Owl Mountain area.

**Average was determined by weighting the mean for individual stand data based on the percent of acreage each stand occupied for the proposed treatment activity.

MPB Ground Survey

Ground survey indicates a building MPB population in the Green Ridge Analysis Area. Ground surveys provide an estimate of currently infested and recently killed trees. A comparison of the numbers of trees infested from year to year expressed as a ratio indicates whether a population is increasing, decreasing, or static and how quickly it may be doing so. Cole and Amman (1980) reported that

MPB infestations measured in Forest Service Regions 2 and 4 indicated the following pattern of an outbreak that is helpful in interpreting ground survey data. Infested trees numbered from 0.5 to 5.0 trees per acre in the early years of an outbreak and increased to 26 to 31 trees per acre during the peak of an outbreak, and declined to 2 to 3.5 trees per acre following the peak of an outbreak. Most of the large diameter trees have been killed by the time the outbreak subsides.

Strip samples in the Willow Creek area indicate a building beetle population. There was 1.0 currently infested tree per acre detected and the 2002:2001 attack ratio was 3.1:1.0 (Table 6).

The systematic survey of the Green Ridge area using 1/50th acre plots indicated an average of 6.9 new infested trees per acre and the 2002:2001 attack ratio was 1.1:1.00. The population is above the outbreak threshold and was relatively static last year (Table 7).

Table 6. Willow Creek Area summary of strip samples and the 2002:2002 MPB attack ratio.

Acres surveyed	251
New (2002) infested trees	247
Old (2001) infested trees	81
New infested trees per acre	1.0
Old infested trees per acre	.3
Ratio 2002:2001	3.1:1

Table 7. Green Ridge Area summary of systematic 1/50th acre plot survey and MPB attack ratio.

Acres surveyed	27
New (2002) infested trees	186
Old (2001) infested trees	176
New infested trees per acre	6.9
Old infested trees per acre	6.5
Ratio 2002:2001	1.1:1

Evaluation of Proposed Treatments

The Green Ridge Analysis Area Environmental Assessment proposed treatment activities (Figure 4) are discussed below for the Willow Creek, Green Ridge, and Owl Mountain areas.

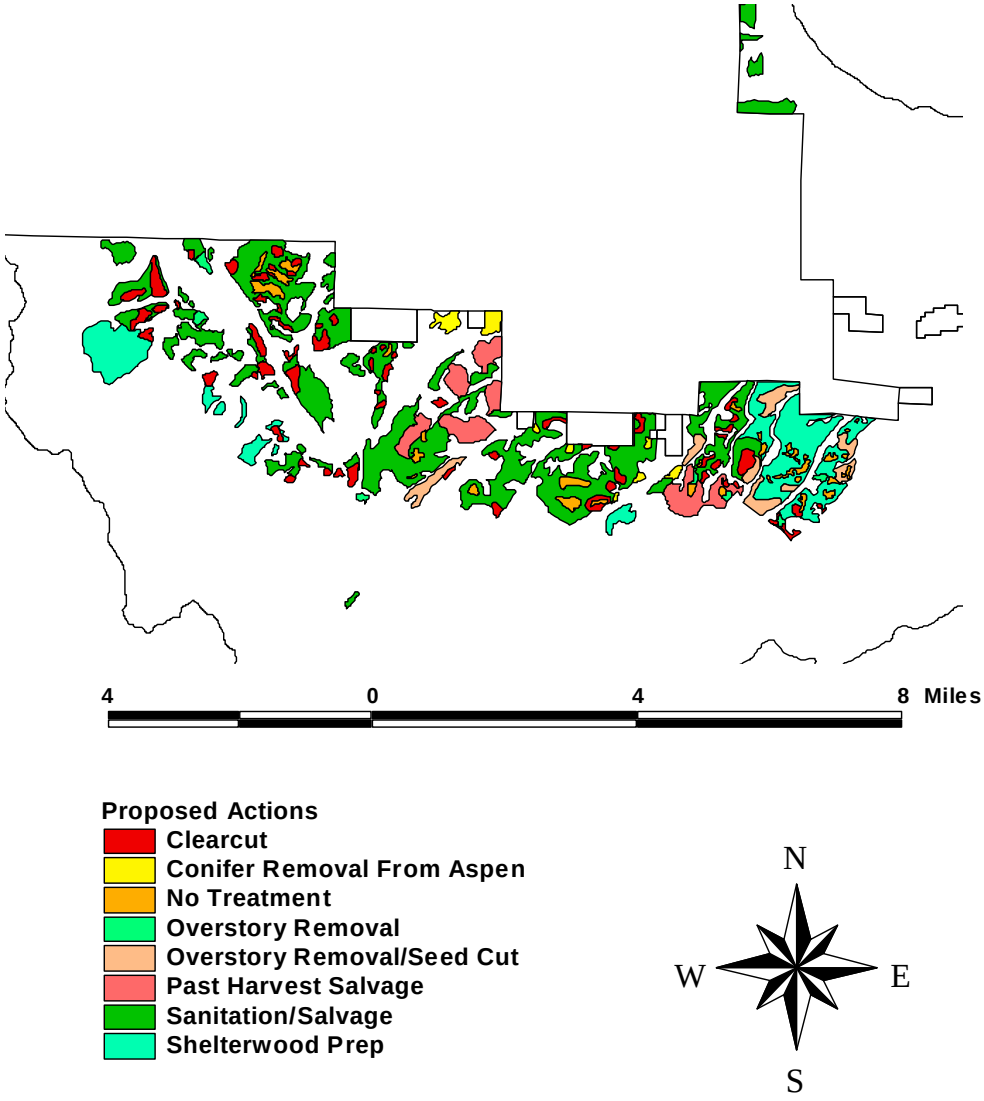


Figure 4. Proposed treatments in the Green Ridge Analysis Area.

Clearcut – Under this treatment all merchantable trees including dead and infested trees will be removed from the site in order to regenerate a new lodgepole or aspen stand. Some thinning of the newly regenerated stand is recommended to help insure the future stand will be more resistant to MPB

attack. Regenerating new lodgepole stands or non-host aspen stands diversify the forest landscape and avoid large areas of contiguous susceptible pine forests in the future.

Willow Creek Area – 338 acres in 29 units are proposed to be clearcut. Current average dbh is 8.5 inches, age is 117 indicating high or moderate risk depending on elevation (Table 3). Average basal area is 151 indicating increased susceptibility to MPB as well. MPB populations appear to be increasing in this area. Removal of heavy pockets of infested trees through clearcutting may slow localized MPB population increases.

Green Ridge Area – 492 acres in 38 units are proposed to be clearcut. Stand conditions here are very favorable for MPB outbreaks. Average dbh is 9 inches, average age is 124 and average basal area is 163 (Table 4). High MPB numbers per acre in this area make continued losses likely. Salvage of infested trees and removal of other merchantable highly susceptible trees will allow a new stand to be regenerated and managed for aspen or thinned in the future to increase MPB resistance.

Owl Mountain area – No clearcuts are planned.

Overstory Removal – This treatment will remove much of the merchantable overstory and all of the infested and dead merchantable trees. Younger trees in the understory will be retained. This treatment will allow salvage of infested and highly susceptible trees and leave a younger, more beetle-resistant stand. This treatment is best where there is little or no dwarf mistletoe present. Dwarf mistletoe infested trees in the residual stand should be cut where possible.

Willow Creek Area – 47 acres over 5 units are proposed for overstory removal and stand basal area will be reduced from an overall average of 121 to 50 (Table 3). Larger trees left behind may be prone to windthrow in this area (see Appendix). Current stand conditions are favorable to MPB with average dbh at 8.3 and average age at 96 (Table 3).

Green Ridge Area – 2 units totaling 43 acres are proposed for overstory removal and average stand basal area will be reduced from 171 to 74. Average diameter of these units is 10.0 and the average age is 114 (Table 4). High numbers of MPB infested trees exist in the area and these stands are currently highly susceptible to MPB.

Owl Mountain Area – No overstory removal is proposed.

Sanitation/Salvage – This treatment is a light partial cutting that will thin the overstory by about 30-40% to improve the health and beetle resistance of the stand. Salvage of dead, beetle infested and diseased trees is emphasized.

Sanitation/salvage is proposed on 53% of the acres proposed for treatment in the Green Ridge Analysis Area.

Willow Creek Area – 2,301 acres in 15 units are proposed. Average dbh is 8.7 inches and average age is 110 years. Basal area will be reduced from 145 to 90 sq. ft. per acre (Table 3). This treatment should leave a more beetle resistant stand and minimize the risk of windthrow (Appendix). Ground survey indicates beetle pressure is lower in this portion of the Analysis Area and preventive treatments may slow increasing MPB populations and reduce MPB-caused mortality.

Green Ridge Area – 1,795 acres in 33 units are proposed for sanitation/salvage treatment. These stands have an average dbh of 9.0 inches, average age of 119 years and an average basal area of 169 (Table 4). The proposed treatments will reduce stand basal area to an average of 98 sq. ft. per acre. This treatment should reduce the attractiveness of the stands to MPB and wind throw losses should be minimized with this residual density. High beetle pressure in the area may result in additional tree losses in treated areas.

Owl Mountain Area – 199 acres in 4 units are proposed for sanitation/salvage. Average basal area will be reduced from 187 to 113 (Table 5). This basal area reduction may make stands less favorable to MPB for a few years, but stand density is still high. Without stand diameter and age information it is impossible to predict how this treatment may affect stand susceptibility. Aerial survey does indicate increasing MPB populations in the area and partial cutting in the stand will likely be beneficial. A heavier cut may be warranted if the residual stand is above 8 inches dbh, over 80 years old and over 120 sq. ft. basal area per acre.

Shelterwood – This proposed action will remove 30-40% of the existing overstory with an emphasis on leaving a healthier stand less susceptible to MPB.

Willow Creek Area – 1,056 acres in 6 management units are proposed for shelterwood cutting. Current stand conditions are favorable to MPB increases. Average dbh is 8.5 inches, average age is 109 and average density is 171 sq. ft. per acre. The proposed action will reduce basal area to an average of to 100 sq. ft. per acre and should help reduce susceptibility to MPB (Table 3).

Green Ridge Area – 556 acres in 7 units are proposed for shelterwood cutting. These include very dense stands of smaller diameter trees. Average diameter is 8.3 inches and average age is 143 years. The proposed action will reduce basal area from 212 to 127 (Table 4). Partial cutting in this area will likely reduce average diameter sufficiently to make the stand less attractive to beetles but additional thinning may be necessary in the future.

The following proposed actions are found only in the Willow Creek Area of the Green Ridge Analysis Area.

Past Harvest Salvage – This treatment is proposed for 727 acres in six units. This is a relatively light partial cut to remove infested and highly susceptible trees in an area that has already been partially cut. Current average dbh and tree age for these areas are 8.5 inches and 103 years. The proposed action will reduce basal area from 132 to 109 (Table 3). This action will likely focus on larger trees and should reduce stand susceptibility. Stand density is still high and future thinning would be beneficial in reducing MPB susceptibility.

Overstory Removal/Seed Cut – This treatment will remove most of the merchantable large trees but will leave a certain number per acre to provide a seed source for the future stand. The risk for windthrow in this situation is very high (see Appendix). 409 acres in 8 units are proposed in highly susceptible MPB stands with an average age of 109 and an average diameter of 9 inches. The proposed action will reduce average basal area from 117 to 51 (Table 3) and should reduce stand susceptibility to MPB.

Conifer Removal from Aspen – This treatment will convert the stand to a predominantly non host type unsuitable for MPB. 114 acres in 7 units are proposed for this treatment. The average diameter for these stands is 8.2 inches and the average age is 98 years. Basal area will be reduced from 127 to 63 sq. ft. per acre (Table 3).

Conclusion

The proximity of infested to uninfested trees is a factor in the short term risk to a given stand of trees (Shore and Safranyik 1992). The high level of MPB activity in the Green Ridge Analysis Area indicates a high risk of infestation to all susceptible stands in the proposed treatment areas.

Where MPB populations are at endemic levels, silvicultural strategies to reduce stand susceptibility by thinning stands to below 100 sq. ft. of basal area per acre and reducing the average tree diameter to less than 8 inches may help prevent outbreak populations from building in treated stands (McGregor et. al. 1987; Amman 1989). Reducing basal area to between 60 and 80 sq. ft. per acre will increase the length of time that stands are resistant to MPB attack. Stands cut to 60 basal area per acre should remain relatively unsusceptible for about 50 years, those cut to basal area 80 for about 25 – 30 years, and those cut to 100 for about 11 to 15 years (Schmid and Amman 1992). Partial cutting lodgepole pine stands presents risk of losing additional trees to windfall and intensifying dwarf mistletoe infection present within the stands. These concerns should be addressed before partial cutting to reduce MPB impacts (Appendix).

Where outbreak MPB populations already exist, direct suppression through removal of infested trees as well as making stand conditions less favorable for

MPB may help to reduce impacts. Cutting, followed by removal or treatment of beetle infested trees, should be considered a priority before beetles begin emergence in July. Logs can be hauled to sawmills where milling will kill the beetles or to "safe sites" at least one mile away from host trees susceptible to the emerging beetles (Appendix). If infested logs are left in or near developed recreation sites, direct suppression of the beetles will be necessary to reduce the threat to uninfested trees. Treatment strategies to kill the beetles before emergence include debarking, chipping, burning, burying, or solar treating. Detailed alternatives and considerations for managing MPB impacts are provided in the Appendix.

Literature cited

Amman, G. D. 1989. Why partial cutting in lodgepole pine stands reduces losses to mountain pine beetle: Proceedings – symposium on the management of lodgepole pine to minimize losses to the mountain pine beetle. General Technical Report INT-262. USDA Forest Service, Intermountain Research Station. Ogden, UT. p. 48-59.

Amman, G. D.; McGregor M. D.; Cahill D. B; Klein W. H. 1977. Guidelines for reducing losses of lodgepole pine to mountain pine beetles in unmanaged stands in the Rocky Mountains. General Technical Report INT-36. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. 19 p.

Cole, W. E.; Amman, G. D. 1980. Mountain pine beetle dynamics in lodgepole pine forests. Part 1: Course of an infestation. General Technical Report INT-89. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. 56 p.

Furniss, R. L.; Carolin, V. M. 1977. Western forest insects. Misc. publication No. 1339. USDA Forest Service. p. 353-356.

Johnson, E. 2002. 2001 Aerial detection survey of the Rocky Mountain Region. 3410 Report – R2-02-09. USDA Forest Service, Rocky Mountain Region, Renewable Resources, Lakewood, CO. 20 p.

McGregor M. D.; Amman, G. D.; Schmitz, R. F.; Oakes, R. D. 1987. Partial cutting lodgepole pine stands to reduce losses to the mountain pine beetle. Canadian Journal of Forest Resources. 17: 1234-1239.

McGregor, M. D.; Cole, D. M. 1985. Integrating management strategies for the mountain pine beetle with multiple resource management of lodgepole pine forests. General Technical Report INT-174. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. 68 p.

Schmid, J. M.; Amman, G. D. 1992. *Dendroctonus* beetles and old growth forests in the Rockies. *In* Kaufman, M. R.; Moir, W. H.; Basset, R. L. (tech. coord.). Old growth forests in the Southwest and Rocky Mountain regions, proceedings of a workshop. General Technical Report RM-213. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. p.51-59.

Schmid, J. M.; Mata, S. A. 1992. Stand density and mountain pine beetle caused tree mortality in ponderosa pine stands. Research Note RM-521. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO. 4 p.

Shore, T. L.; Safranyik, L. 1992. Susceptibility and risk rating systems for the mountain pine beetle in lodgepole pine stands. Information Rep. BC-X-336. Victoria, BC: Forestry Canada, Pacific and Yukon Region, Pacific Forestry Centre. 12 p.

Appendix

Action Alternatives for Managing Mountain Pine Beetle Impacts in Lodgepole Pine Stands

USDA Forest Service, Region 2 Forest Health Management

Management Alternatives

Several actions are available to reduce pine mortality due to attack by mountain pine beetle (MPB), *Dendroctonus ponderosae* Hopkins (Order Coleoptera; Family Scolytidae). Reduction of MPB-caused tree mortality can be accomplished by management of host stand conditions (indirect actions) or by management of the MPB population (direct actions). Suppression of large-scale MPB epidemics is hypothetically possible, especially during the early phase of an epidemic, but it is unlikely due to the major physical and financial commitment required. Prevention should be emphasized where MPB impacts are undesirable. The only strategy is to alter stand conditions to be less susceptible to mortality from MPB. Once undesirable MPB-caused mortality has begun, the intent of forest management should be to reduce adverse impacts to affected areas and minimize spread to adjacent stands. The decision to take a particular action(s) should be based on management objectives, economic factors, MPB population status and trends, stand conditions, location, resource values at risk, and other relevant issues. Consideration of MPB in the context of overall land management is important. Focusing on MPB alone may amplify other problems, such as dwarf mistletoe infestation (Hawksworth and Johnson 1989). One or a combination of the following action alternatives may be useful in most situations.

Alternative 1: No Action

The "No Action" alternative accepts MPB-caused tree mortality and associated impacts as a natural phenomenon. As a native insect, MPB has been active for thousands of years and is one of the most important biotic causes of pine mortality across the West (Amman et al. 1989). MPB populations increase and decrease without obvious direct human influence but some human activities may benefit the beetle. Fire suppression has helped create stand conditions that are more susceptible to MPB infestation. Construction injury to trees from home and road building can contribute to MPB survival by creating susceptible trees near MPB-infested trees and thereby decrease dispersal-related beetle mortality. Epidemics of MPB have many ramifications in addition to the creation of dead

pine trees (Schmid and Amman 1992). These impacts vary depending upon the extent, intensity, and duration of the MPB epidemic.

Where to use – Use where other alternative actions are not desired, cannot be implemented or will not be effective. One example may be designated wilderness areas.

Advantages – No mechanical site disturbance or introduction of foreign materials into the environment will occur. Understory vegetation may prosper. From extensive and intense MPB epidemics, water yield and possibly annual stream flow will increase for a time interval before stands regenerate (McGregor and Cole 1985). Tree regeneration may be facilitated by increased sunlight reaching the forest floor. Changes in vegetation and cover may be advantageous to certain wildlife species, particularly those that utilize dead trees. Successional trends may benefit management objectives. Some people will prefer the decision to let nature take its course. Resources could be redirected to managing uninfested stands to minimize future MPB impacts.

Disadvantages – The "no action" alternative means no silvicultural or chemical activity will be undertaken to change a stand's resistance to MPB population increase and spread. Dead trees can become safety hazards over time as they rot and fall. Timber values are reduced or lost. Increased stream flow could affect stream bank stabilization. MPB epidemics may adversely affect visual quality by creating large numbers of dead and dying trees. The presence of fallen trees may affect travel and recreation within affected stands. Fire hazard and ignition potential will be increased during the period when dry needles are present on recently killed pines and there will be increased heavy fuel buildup after dead trees fall to the ground (Cole and Amman 1980). Regeneration may be inhibited due to loss of seed source in severe widespread epidemics, the covering effect of dead fallen trees, and lack of seedbed preparation. Changes in vegetation and cover may not be advantageous to certain wildlife species. Successional trends may not meet management objectives. Public sentiment may be unfavorable, even in situations where a MPB epidemic cannot be stopped by direct action. The aforementioned disadvantages may be compounded in settings like the wildland-urban interface, where some management response is warranted.

Alternative 2: Silvicultural Treatment

Silvicultural prescriptions improving stand health, enhancing tree growth, and increasing tree spacing will reduce or prevent MPB-caused tree mortality (Amman 1989; Schmid and Mata 1992). The most recommended long-term tactic to minimize losses to MPB is to partially cut susceptible stands or harvest

and subsequently replace susceptible stands. Removal of individual pines of low vigor and poor health will lessen the chance of a MPB outbreak. Lodgepole pine stands at high risk to MPB are those at lower elevation-latitudes where average tree diameter exceeds 8 inches and average tree age exceeds 80 years (Amman et al. 1977). Favorable conditions for MPB in ponderosa pine stands are those where average tree diameter is greater or equal to than 8 inches and basal area is greater than or equal to 120 square feet per acre (Schmid and Mata 1992). The 120 sq. ft. basal area threshold may also be pertinent in lodgepole pine stands. Studies in lodgepole pine found greater losses in stands thinned to 120 sq. ft. basal area and in unthinned control plots compared to stands thinned to 100 or less sq. ft. basal area per acre (McGregor et al. 1987). Partial cutting that reduces stands to 60 - 80 square feet of basal area per acre or less and average tree diameter to below 8 inches reduces stand susceptibility to MPB. When partially cutting susceptible stands, care must be taken to avoid leaving dense pockets of mature pines, because these areas can serve as foci for MPB attack (McGregor et al. 1987).

The risk of windfall must also be considered when partially cutting lodgepole pine stands but is usually not a problem in ponderosa pine stands. Soil depth and stand density contribute to wind firmness as does stand exposure. Alexander (1972) describes windfall risk based on exposure as follows:

Low Windfall Risk Situations

1. Valley bottoms except where parallel to prevailing winds and all flat areas.
2. All lower and gentle middle north and east facing slopes.
3. All lower gentle middle south and west facing slopes that are protected by considerably higher ground not far to windward.

Moderate Windfall Risk Situations

1. Valley bottoms parallel to the direction of prevailing winds.
2. All lower and gentle middle south and west facing slopes not protected to the windward direction.
3. Moderate to steep middle and all upper north and east facing slopes.
4. Moderate to steep middle south and west facing slopes protected by considerable higher ground not far to windward.

High Windfall Risk Situations

1. Ridgetops.
2. Moderate to steep middle south and west facing slopes not protected to the windward, and all upper south and west facing slopes.
3. Saddles on ridgetops.

Windfall risk is increased in the above situations by poor drainage, shallow soil and defective roots and boles

Acceptable cutting methods recommended to reduce a stand's risk to MPB include commercial thinning, shelterwood cutting, and overstory removal. Seed tree cuts can work with ponderosa pine but generally should not be considered for lodgepole pine due to the likelihood of windfall. Seed tree cuts that are part of a two- or three-step shelterwood cut and are instigated after one or two partial cuts may be more windfirm and could be considered in lodgepole pine stands. In lodgepole pine stands that are lightly infested with MPB, all trees that are attacked may be removed along with the most susceptible trees without going below standard basal area prescriptions. Heavily infested stands can be addressed with greater partial cuts in ponderosa pine but are generally not advised in lodgepole pine stands because of windthrow problems.

Clearcutting is also a useful tool to create conditions favorable to regenerating lodgepole pine and converting mature stands to younger stands. Block or patch cutting within extensive areas of pure even aged stands of lodgepole pine can reduce the potential for MPB epidemics by reducing the area likely to be infested at one time. In addition, clearcutting is generally preferable to partial cutting in lodgepole stands that are understocked or heavily infested by dwarf mistletoe (Alexander 1974). Partial cutting is not recommended where the stand dwarf mistletoe rating is above 3 (Hawksworth and Johnson 1989).

Where to use – Partial cutting is a preventive treatment that addresses long-term tree and stand health. It should be incorporated into land management activity wherever MPB impacts are considered undesirable or are to be minimized. It is particularly important where timber values are the highest priority. It can also be used in and around campgrounds, and in wildland/urban interface areas.

Advantages – Silvicultural treatment reduces the susceptibility of trees to MPB attack and has been shown to limit pine mortality from MPB in forest stands (Amman and others 1977). While this alternative does not guarantee immunity from MPB infestation, it enhances tree growth and decreases susceptibility to MPB infestation. Cutting green trees prior to MPB infestation maximizes economic return from timber resources, because MPB-killed trees are usually less valuable. If applied on a landscape scale, silvicultural treatments could result in a mosaic of stand susceptibility to MPB, which may reduce the development of large-scale MPB epidemics. Silvicultural treatments may allow managers to manipulate the landscape to meet management objectives better than what might be achieved through MPB epidemics and stand replacing fires. Silvicultural treatments in combination with fuels mitigation yield multiple resource benefits.

Disadvantages – This action is not suitable for areas where tree cutting is undesirable, unaffordable or prohibited. Examples of such areas may include wilderness, steep slopes, and where the visual quality of cut areas would be less than that of dead trees. Silvicultural activities are not possible in areas where timber harvesting firms do not exist. There are varying opinions about whether cutting during the beetle flight period may attract beetles to an area and exacerbate the problem. Fresh cut logs and stumps emit volatile compounds such as myrcene, alpha-pinene, and terpinolene which have shown a weak attractiveness to MPB. For large landowners, the forest health benefits ought to outweigh an increased risk of MPB infestations.

Alternative 3: Sanitation and Salvage Harvesting

Sanitation harvesting is a treatment applied to currently infested pine stands. Green trees with immature MPB developing under the bark are cut and removed to an area at least one mile from susceptible pines or processed at a mill prior to MPB emergence. Sanitation must be completed prior to July, when MPB emerges, to be effective. Salvage harvesting is the cutting of MPB-killed trees from which the beetles have emerged and are no longer present. Salvage does not reduce MPB populations but is commonly done in conjunction with sanitation.

Where to use – Stands that are currently under attack where reduction of the MPB population and recovery of timber resource values is desirable and where timber harvesting activity is acceptable. Especially appropriate are infested stands in proximity to uninfested, susceptible high value stands where mortality from MPB would threaten land management objectives. Sanitation could also be used concurrently with silvicultural treatment in stands where the MPB population has not yet reached epidemic levels. Sanitation harvests also are appropriate for private landowners, the wildland/urban interface and developed recreation sites.

Advantages – MPB populations can be significantly reduced by removing most or all infested trees prior to the emergence of the next generation of beetles. Sanitation provides a degree of protection to surrounding, uninfested trees and stands by removing a nearby source of beetles. Timber value could be recovered that would otherwise be lost. Initial increased fire potential from dead trees holding dry needles is reduced and future fire danger from heavy fuels created by dead and down trees is reduced. The visual impact of dead and dying trees is reduced. The hazard from falling trees is lowered. Pine regeneration will be encouraged by both the site disturbance and the reduction in shade. Sanitation cutting combined with partial cutting to include susceptible trees along with infested trees can potentially suppress outbreaks.

Disadvantages – Trees must be removed before MPB emergence. Sanitation/salvage harvesting has not been demonstrated to suppress MPB populations on a scale larger than the individual stand, although this may occur in some cases. It should not be considered an effective control tactic across large landscapes or during severe MPB epidemics where MPB immigration into treated stands is likely. Sanitation/salvage harvesting undertaken without additional considerations for stand health and survival can lead to residual conditions that have other significant problems, such as increased spread and intensification of dwarf mistletoe (McGregor and Cole 1985) or increased risk of wind fall. Tree removal may not be aesthetically acceptable in some areas. Adverse site and soil disturbance may occur.

Alternative 4: Individual Infested Tree Treatment

Individual MPB-infested trees can be cut and treated in a variety of ways to kill and prevent beetle brood from emerging. Any action that kills most or all of the MPB within infested trees prior to MPB emergence falls under this direct control action alternative. **The following methods do not work in all situations and are not all supported by rigorous research results.** Examples of infested tree treatment techniques are: (1) Cut and burn on site; (2) Cut and bury at least 6 inches deep on site; (3) Cut and chip; (4) Cut and remove the bark from infested portions of logs before the immature MPB transform to adult beetles; (5) Cut and expose to direct sunlight such that the trunk surface receives sufficient heat to kill the beetles under the bark, rotating the trunk to ensure complete exposure (Negron et al. 2001); (6) Cut and cover with thick clear plastic such that the trunk surface receives sufficient heat to kill the beetles under the bark (Negron et al. 2001). It is important to check any treatment near the end of June before adult beetle emergence. Each of these methods needs to be completed before the MPB emergence period. Infested-tree treatments differs from sanitation harvesting (Alternative 3) because it is usually applied on a smaller scale and is often not conducted in conjunction with salvage harvesting.

Where to use – This alternative is most appropriate for treating small spots in areas of great concern, such as those adjacent to residences and within developed recreation sites. It may also be appropriate in unroaded areas, on slopes too steep to harvest with conventional methods, in areas where the disturbance from conventional harvest activity is unacceptable, and in areas where there is no possibility of sanitation/salvage harvesting due to insufficient volume, no bids or other reasons.

Advantages – Much of the immature MPB population can be eliminated from the treated area. Infested-tree treatment reduces risk to surrounding uninfested trees is reduced by removing a nearby source of beetles. This alternative may also provide time for silvicultural treatment to be

implemented. The fire hazard from the presence of dead pines retaining dry needles is lowered. The visual impact of dead and dying trees is reduced. The subsequent hazard from falling trees is lowered. Pine regeneration may be encouraged by the reduction of shade. Firewood may be recovered from this treatment.

Disadvantages – There is little time for implementation, because the developing MPB brood must be destroyed before the next emergence period in July. Localized beetle populations can be suppressed by this action, but it rarely reduces a stand's susceptibility to MPB attack. Additional follow-up treatments may be needed in subsequent years because it can be difficult to locate and treat all infested trees in an area. Infested trees may be inadvertently moved as firewood prior to MPB emergence, possibly spreading the infestation. Once beetle populations are increasing exponentially, it is difficult to effectively reduce beetle numbers. There is a very short window of time between discovery of a developing MPB population and initiating direct control measures. Direct control measures must be undertaken in suitable locations. Unsuitable locations include slopes with northern aspects and dense residual stands that will reduce the solar radiation enough not to kill the beetle brood. If solar treatments are not conducted properly, and the infested trees are moved as firewood to locations next to buildings, the risk of creating infested trees near structures is increased.

Alternative 5: Protection of High Value Trees

High value trees can be protected from MPB attack by spraying their boles with an EPA-approved insecticide prior to the MPB attack period.

Where to use – This action is appropriate individual trees of high value in developed recreation sites, ski areas and the wildland/urban interface when there is a threat from active MPB populations in the vicinity. Because specialized equipment may be required, trees must be relatively accessible. This action is not effective for trees that are already infested by MPB.

Advantages – Controlled experiments and operational experiences have established this action as very effective in protecting individual pines from infestation. Specific formulations of carbaryl and permethrin are currently labeled for this use. Protection using carbaryl has been demonstrated to last from 10 - 18 months, meaning that a late spring application may afford two years of protection (Hastings and others 2001).

Disadvantages – Carbaryl and permethrin are toxic to insects other than MPB. Insecticide applied as protection does not effectively reduce the

beetle population or address stand susceptibility to future MPB outbreaks. It does not guarantee absolute protection, especially if the application is not thorough and complete. Insecticide treatment can be very expensive, especially if many trees require treatment. Potential environmental hazards exist from improper use, storage or disposal of chemicals and chemically treated wood. There may be a shortage of qualified pesticide applicators. Many citizens have concerns about environmental contamination and safety.

Literature cited

Alexander, R. R. 1972. Partial cutting practices in old-growth lodgepole pine. Research Paper RM-92. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 16 p.

Alexander, R. R. 1974. Silviculture of central and southern Rocky Mountain forests: A summary of the status of our knowledge by timber types. Research Paper RM120. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO. 36 p.

Amman, G. D. 1989. Why partial cutting in lodgepole pine stands reduces losses to mountain pine beetle. *In* Proceedings – symposium on the management of lodgepole pine to minimize losses to the mountain pine beetle. General Technical Report INT-262. USDA Forest Service, Intermountain Research Station. Ogden, UT. p. 48-59.

Amman, G. D.; McGregor M. D.; Dolph, R. E. Jr. 1989. Mountain pine beetle. USDA Forest Service Leaflet 2. USDA Forest Service, Washington, DC. 11 p.

Amman, G. D.; McGregor M. D.;Cahill, D. B.; Klein, W. H. 1977. Guidelines for reducing losses of lodgepole pine to mountain pine beetles in unmanaged stands in the Rocky Mountains. General Technical Report INT-36. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. 19 p.

Cole, W. E.; Amman, G. D. 1980. Mountain pine beetle dynamics in Lodgepole pine forests. Part 1: Course of an infestation. General Technical Report INT-89. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. 56 p.

Hastings, F. L.; Holsten, E. H.; Shea, P. J.; Werner, R. A. 2001. Carbaryl: a review of its use against bark beetles in coniferous forests of North America. Environmental Entomology 30: 803-810.

Hawksworth, F.G.; Johnson, D.W. 1989. Biology and management of dwarf mistletoe in lodgepole pine in the Rocky Mountains. General Technical Report RM-169: USDA, Forest Service, Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO. 38 p.

McGregor, M. D.; Cole D. M. 1985. Integrating management strategies for the mountain pine beetle with multiple resource management of lodgepole pine forests. General Technical Report INT-174. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. 68 p.

McGregor, M. D.; Amman, G. D.; Schmitz, R. F.; Oakes, R. D. 1987. Partial cutting lodgepole pine stands to reduce losses the mountain pine beetle. Canadian Journal of Forest Resources. 17: 1234-1239.

Negron, J. F.; Shepperd W. D.; Mata, S. A.; Popp, J. B.; Asherin, L. A.; Schoettle, A. W.; Schmid, J. M.; Leatherman, D. A. 2001. Solar treatments for reducing survival of mountain pine beetle in infested ponderosa and lodgepole pine logs. Research Paper RMRS-RP-30. USDA Forest Service Rocky Mountain Research Station, Fort Collins, CO. 11p.

Schmid, J. M.; Amman, G. D. 1992. *Dendroctonus* beetles and old growth forests in the Rockies. *In* Kaufman, M. R.; Moir, W. H.; Basset, R. L. (tech. coord.). Old growth forests in the Southwest and Rocky Mountain regions, proceedings of a workshop. General Technical Report RM-213. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. p.51-59.

Schmid, J. M.; Mata, S. A. 1992. Stand density and mountain pine beetle caused tree mortality in ponderosa pine stands. Research Note RM-521. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO. 4 p.